

Research on the Oilfield Output Optimization Model

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Abstract

A scheme of synthetic adjustment of all the chokes to increase oilfield output based on the actual production data obtained from one of the oilfields, was proposed in this paper. The relationship between chokes and output was investigated, and the method of choke adjustment was discussed. The results showed that the total output was increased significantly after optimization, except for the reduction from part of oil wells. According to these results, it can be proved that the method is efficient and simple with great practical value.

Keywords

Oilfield; Output Optimization; Choke Adjustment

Introduction

Petroleum industry is one of the main energy industries in China. Petroleum production should provide hydrocarbon resources for national construction based on the principle of efficiency and energy-saving. There are many methods and angles in measure programming and optimized production forecast, such as production distribution of oilfield development, swabbing parameter of pumping well, well distribution, injection-production parameters, and water injection mode^{[1-6][8][9][13]}.

Optimization whose main objective is cost is generally carried out in continental oilfields. Yin Aizhen in China University of Petroleum has proposed a optimization model of oilfield output from the perspectives of the acquisition of the maximum economic benefit, which was targeted at profit maximization under the condition of multi-restrictions^[11]. Oilfield output was optimized by Wang Fang, who considered its lowest cost as objective function^[10].

Continental oilfield are so distinct that output of production wells is required to reach the maximum in a shorter time because of its about 20-years-old service life. Meanwhile, the whole efficiency of the production

system needs to maintain at relatively high level. A method of optimum adjustment of the size of all wells was adopted in this paper in which maximum total output and minimum cost were achieved by means of the introduction of a group of optimal combination of chokes.

Method of Choke Adjustment

The back pressure of the system has a direct impact on each well, which is determined by all the wells on the platform. The fluctuation of production parameters of wells is caused by the changes of back pressures of wellheads. All of the wells should be optimized to balance, because the working condition of wells would be changed when single well parameter was adjusted. Thus it is a wrong concept that single choke with big size can bring a higher output. Due to the location of chokes and non-complex operations required, choke adjustment is considered as the most direct and efficient way to control production systems.

Mathematical Model of Choke and Sensitivity Function

Choke is divided into 4 sections and only the mixture of oil, gas and water through choke is analyzed, which is showed in Fig. 1.

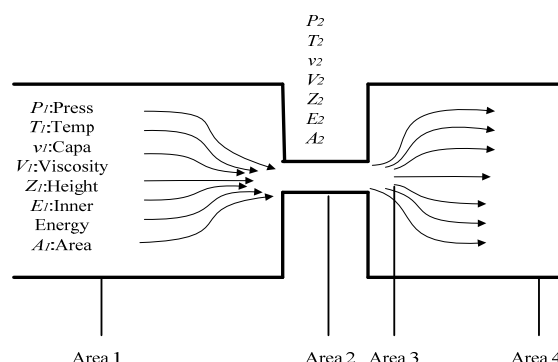


FIG.1 DATAFLOW OF FLUIDS THROUGH CHOKES

When oil pressure maintains a certain value, the mass

flow is the function of back pressure under the condition of subcritical flow. Therefore, a theoretical model of critical flow and subcritical flow is established based on thermodynamics^{[7][12][14]}.

$$V_2 = \sqrt{\frac{288g_c \{ \lambda p_1 v_1 [1 - p_r^{(n-1)/n}] + [(f_o / \rho_o) + (f_g / \rho_g)] p_1 (1 - p_r) \}}{1 - (A_2 / A_1)^2 [(f_g + \alpha_1) / (f_g p_r^{-1/n} + \alpha_1)]^2}} \quad (1)$$

According to the equation above, take derivatives of the diameter of choke d_c , which exactly is the sensitivity function.

$$V_2' = 2\beta \left[1 - \left(\frac{d_c}{d_1} \right)^4 \left(\frac{f_g + \alpha_1}{f_g p_r^{-1/n} + \alpha_1} \right)^2 \right]^{\frac{3}{2}} \left[\left(\frac{f_g + \alpha_1}{f_g p_r^{-1/n} + \alpha_1} \right)^2 \frac{d_c^3}{d_1^4} \right] \quad (2)$$

The sensitivity of choke diameter for output is confirmed according to the derivation of equation above, which can indicate the impact of adjustment of the chokes on output based on production data. Comparison and sorting is done after calculating the sensitivity function, and then the choke to be adjusted at first is determined. This method can reduce the number of chokes to adjust, shorten the adjustment time and increase the output of platform and efficiency of the system.

Calculation of Choke Adjustment

Beginning with calculation of the back pressure, oil pressure is changed certainly due to the adjustment of a certain choke based on the model of choke flow. Under the current production oil pressure, new flowing pressure of the bottom hole will be obtained by means of calculation of pipe flow and the characteristics model of electric submersible pump. Liquid-production value is gained by the curve of productivity prediction, from which oil pressure value is got. The back pressure is averaged with the initial value after it is obtained through chokes, and calculation is done again till the steady of production is achieved.

Chokes are adjusted circularly till the maximum of output is gained.

Application Example and Analysis

Optimization calculation was done based on the actual data of one of the oilfields. The step of adjustment for chokes was 0.1nm during the process of optimization.

Although output of others were not increased, or even reduced, the total output was increased significantly. The collective information is showed in Table 1.

TABLE 1 COMPARISON OF PRE- AND POST INDEXES OF PLATFORM

	Unoptimized	Optimized	Comparing
Liquid(m ³ /d)	3516.15	3827.78	+311.63
Oil(t/d)	2441.25	2582.06	+140.81
Press(MPa)	0.848	0.924	+0.08
Electricity Per Ton Liquid(kWh/m ³)	5.40	5.07	-0.33
Electricity Per Ton Oil(kWh/t)	7.78	7.52	-0.26
Efficiency(%)	27.43	28.06	+0.63

Results showed that liquid-producing capacity and oil production have increased by 311.63 m³ and 140.81 t, meanwhile, the back pressure was increased by 0.08 Mpa. Otherwise, electricity consumption was reduced and the efficiency of the system was increased significantly.

Conclusions

By adjustment of the chokes, the total output was optimized according to the characteristic of oilfield in this paper. This method is featured with obvious effect and strong operability, which has broad prospects in the application of oilfield.

Due to the small step of adjustment and large numbers of wells, which leads to large number of combinations of chokes of all the wells, the complex computation and long computing time. So optimizing the calculation method is a key problem that needs to further study.

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